电机学六、七章作业答案

6-1、有一三相电机，Z=36、2P=6，a=1，采用单层链式绕组，试求：

（1）绕组因数 K_{N1}、K_{N5}、K_{N7}；（2）画出槽导体电动势星形图；

（3）画出三相绕组展开图（只画 A 相）；

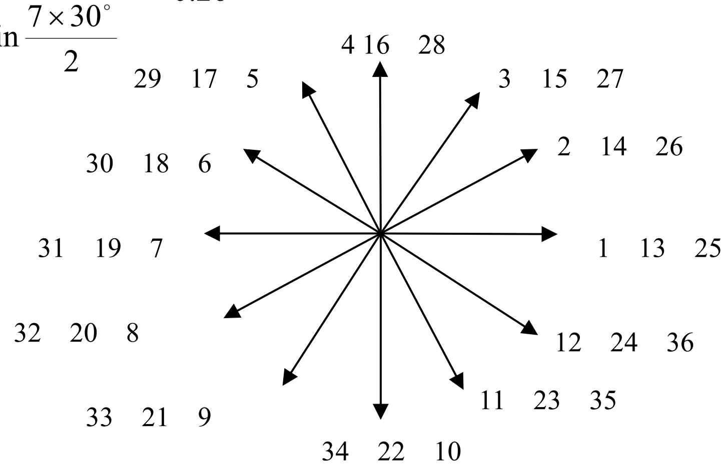
解：（1）由已知可得：$q=\frac{Z}{2Pm}=\frac{36}{6\times 3}=2$ $\alpha=\frac{360^{\circ}\times P}{Z}=\frac{360^{\circ}\times 3}{36}=30^{\circ}$

$$K_{N1}=K_{d1}=\frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}}=\frac{\sin\frac{2\times 30^{\circ}}{2}}{2\times\sin\frac{30^{\circ}}{2}}=0.97$$

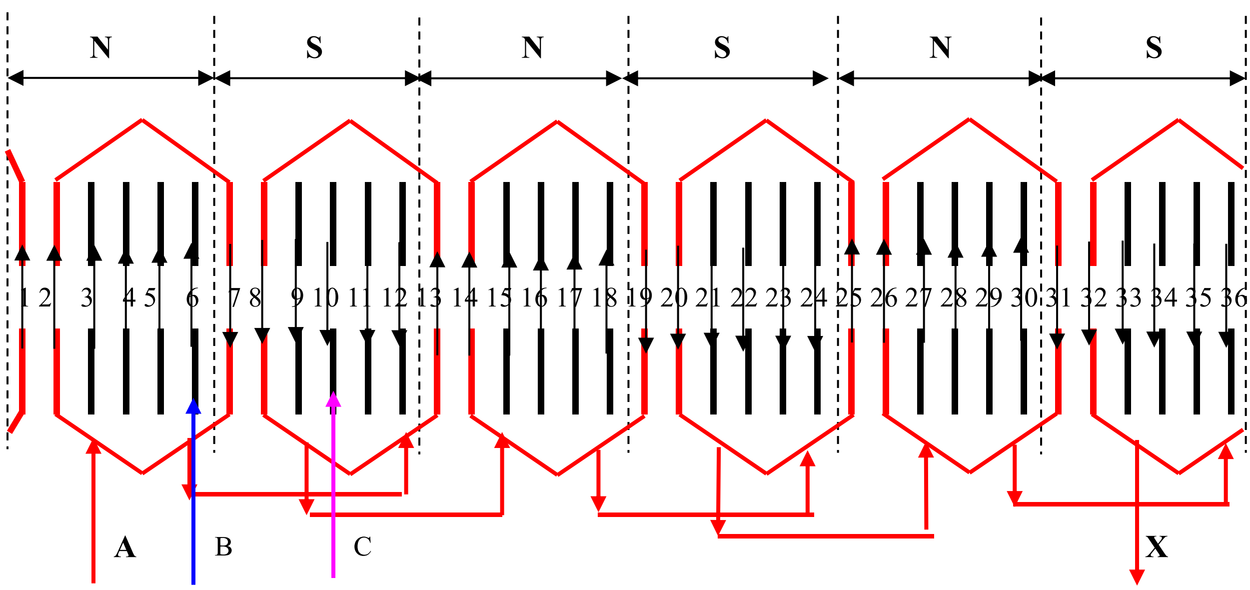
$$K_{N5}=K_{d5}=\frac{\sin\frac{5q\alpha}{2}}{q\sin\frac{5\alpha}{2}}=\frac{\sin\frac{5\times 2\times 30^{\circ}}{2}}{2\times\sin\frac{5\times 30^{\circ}}{2}}=0.26$$

$$K_{N7}=K_{d7}=\frac{\sin\frac{7q\alpha}{2}}{q\sin\frac{7\alpha}{2}}=\frac{\sin\frac{7\times 2\times 30^{\circ}}{2}}{2\times\sin\frac{7\times 30^{\circ}}{2}}=-0.26$$

（2）槽导体电动势星形图



（3）绕组展开图



6-2、有一三相电机，Z=36、2P=4，y=7τ/9，a=1，双层叠绕组，试求：

（1）绕组因数 K_{N1}、K_{N5}、K_{N7}；（2）画出槽导体电动势星形图；

（3）画出三相绕组展开图（只画 A 相，B、C 两相只画出引出线端部位置）；

解：（1）由已知可得： $q=\dfrac{Z}{2Pm}=\dfrac{36}{4\times 3}=3$ $\qquad \alpha=\dfrac{360^\circ\times P}{Z}=\dfrac{360^\circ\times 2}{36}=20^\circ$

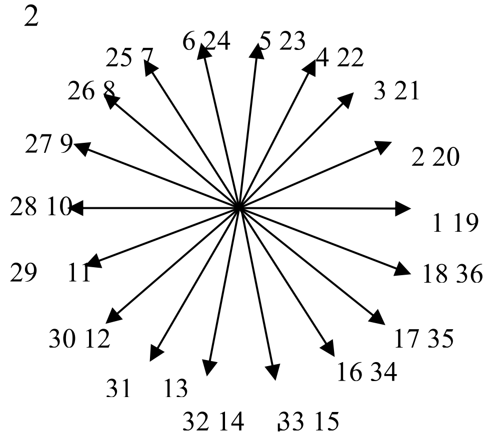
$$\beta=\frac{\tau-y}{\tau}\cdot 180^\circ=\frac{9-7}{9}\times 180^\circ=40^\circ$$

$$K_{N1}=K_{d1}K_{p1}=\frac{\sin\dfrac{q\alpha}{2}}{q\sin\dfrac{\alpha}{2}}\cos\frac{\beta}{2}=\frac{\sin\dfrac{3\times 20^\circ}{2}}{3\times\sin\dfrac{20^\circ}{2}}\times\cos\frac{40^\circ}{2}=0.96\times 0.94=0.90$$

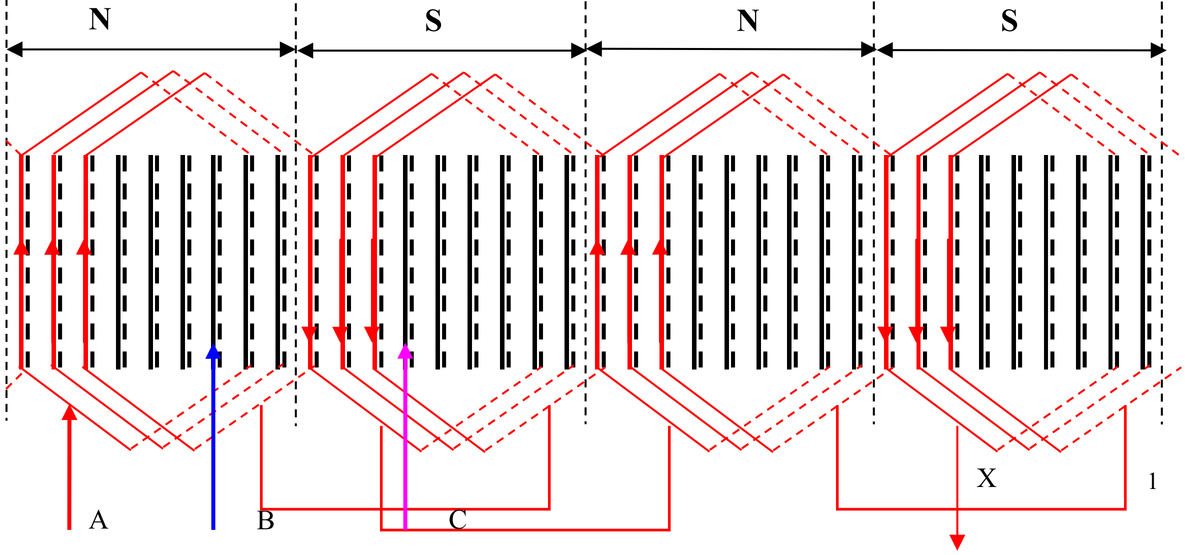
$$K_{N5}=K_{d5}K_{p5}=\frac{\sin\dfrac{5q\alpha}{2}}{q\sin\dfrac{5\alpha}{2}}\cos\frac{5\beta}{2}=\frac{\sin\dfrac{5\times 3\times 20^\circ}{2}}{3\times\sin\dfrac{5\times 20^\circ}{2}}\times\cos\frac{5\times 40^\circ}{2}=0.22\times(-0.174)=-0.04$$

$$K_{N7}=K_{d7}K_{p7}=\frac{\sin\dfrac{7q\alpha}{2}}{q\sin\dfrac{7\alpha}{2}}\cos\frac{7\beta}{2}=\frac{\sin\dfrac{7\times 3\times 20^\circ}{2}}{3\times\sin\dfrac{7\times 20^\circ}{2}}\times\cos\frac{7\times 40^\circ}{2}=-0.18\times(-0.77)=0.14$$

（2）槽导体电动势星形图



（3）A 相绕组展开图



6-3、有一三相电机，Z=48，2p=4，a=1，每相串联导体数 N=96，f=50Hz，双层短距绕组，星形接法，每极磁通 Φ_1=1.115×10^{-2} Wb，Φ_3=0.365×10^{-2} Wb，Φ_5=0.24×10^{-2} Wb，Φ_7=0.093×10^{-2} Wb，试求：（1）力求削弱 5 次和 7 次谐波电动势，节距 y 应选多少？（2）此时每相电动势 E_ϕ；（3）此时线电动势 E_1；

解： $\tau = \dfrac{Z}{2p} = \dfrac{48}{4} = 12$，**为了削弱 5、7 次谐波，取：** $y = \dfrac{5\tau}{6} = 10$，$q = \dfrac{Z}{2pm} = \dfrac{48}{4\times 3} = 4$

$$\beta = (1-\frac{y}{\tau})\pi = (1-\frac{10}{12})\times 180^\circ = 30^\circ \qquad \alpha = \frac{p\times 360^\circ}{Z} = \frac{2\times 360^\circ}{48} = 15^\circ$$

$$\therefore \quad K_{N1} = K_{d1}K_{p1} = \frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}}\cos\frac{\beta}{2} = \frac{\sin\frac{4\times 15^\circ}{2}}{4\times\sin\frac{15^\circ}{2}}\times\cos\frac{30^\circ}{2} = 0.96\times 0.97 = 0.93$$

$$K_{N3} = K_{d3}K_{p3} = \frac{\sin\frac{3q\alpha}{2}}{q\sin\frac{3\alpha}{2}}\cos\frac{5\beta}{2} = \frac{\sin\frac{3\times 4\times 15^\circ}{2}}{4\times\sin\frac{3\times 15^\circ}{2}}\times\cos\frac{3\times 30^\circ}{2} = 0.707\times 0.653 = -0.46$$

$$K_{N5} = K_{d5}K_{p5} = \frac{\sin\frac{5q\alpha}{2}}{q\sin\frac{5\alpha}{2}}\cos\frac{5\beta}{2} = \frac{\sin\frac{5\times 4\times 15^\circ}{2}}{4\times\sin\frac{5\times 15^\circ}{2}}\times\cos\frac{5\times 30^\circ}{2} = 0.205\times 0.259 = 0.053$$

$$K_{N7} = K_{d7}K_{p7} = \frac{\sin\frac{7q\alpha}{2}}{q\sin\frac{7\alpha}{2}}\cos\frac{7\beta}{2} = \frac{\sin\frac{7\times 4\times 15^\circ}{2}}{4\times\sin\frac{7\times 15^\circ}{2}}\times\cos\frac{7\times 30^\circ}{2} = -0.157\times(-0.259) = 0.041$$

$$\therefore \quad E_{\phi 1} = 4.44 f_1 N K_{N1}\Phi_{m1} = 4.44\times 50\times 96\times 0.93\times 1.15\times 10^{-2} = 219.8(V)$$

$$E_{\phi 3} = 4.44 f_3 N K_{N3}\Phi_{m3} = 4.44\times 50\times 3\times 96\times 0.46\times 0.365\times 10^{-2} = 105.2(V)$$

$$E_{\phi 5} = 4.44 f_5 N K_{N5}\Phi_{m5} = 4.44\times 50\times 5\times 96\times 0.053\times 0.24\times 10^{-2} = 13.6(V)$$

$$E_{\phi 7} = 4.44 f_7 N K_{N7}\Phi_{m7} = 4.44\times 50\times 7\times 96\times 0.041\times 0.093\times 10^{-2} = 5.7(V)$$

$$\therefore \quad E_\phi = \sqrt{E_{\phi 1}^2 + E_{\phi 3}^2 + E_{\phi 5}^2 + E_{\phi 7}^2} = \sqrt{219.8^2 + 105.2^2 + 13.6^2 + 5.7^2} = 244(V)$$

$$E_l = \sqrt{3}\times\sqrt{E_{\phi 1}^2 + E_{\phi 5}^2 + E_{\phi 7}^2} = \sqrt{3}\times\sqrt{219.8^2 + 13.6^2 + 5.7^2} = 381.5(V)$$

6．3 有一三相电机，z=48,2p=4,a=1,每相串联导体数 N=96,f=50Hz,双层短距绕组，星型接法，每极磁通 $\phi_1 = 1.115\times10^{-2}Wb$，$\phi_3 = 0.365\times10^{-2}Wb$，$\phi_5 = 0.24\times10^{-2}Wb$，$\phi_7 = 0..93\times10^{-2}Wb$，试求：

（1） 力求削弱 5 次和 7 次谐波电动势，节距 y 应选多少？

（2） 此时每相电动势 E_ϕ；

（3） 此时线电动势 E_1；

解：（1）同时削弱 5 次和 7 次谐波电动势，节距应选短距角为 $(\frac{1}{5}\sim\frac{1}{7})\tau$，现取 y=10，槽数 Z=48，4 极，极距 $\tau_p = \frac{Z}{2p}$，$\tau_p = \frac{48}{4} = 12$，$y < \tau_p$ 短距，短距角 $\beta = (\tau_p - y)\alpha = 2\times15^0 = 30^0$。

（2）每极每相槽数 $q = \frac{Z}{2mp} = 4$，$q\alpha = 60^0$ 相带

槽距角 $\alpha = \frac{60^0}{q} = 15^0$

基波分布因数 $K_{d1} = \dfrac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}} = 0.958$

基波节距因数 $K_{p1} = \cos\frac{\beta}{2} = 0.966$

基波绕组因数 $K_{N1} = K_{d1}K_{p1} = 0.958\times0.966 = 0.925$

同法分别可以得到 3 次、5 次、7 次谐波的绕组因数分别为：

$K_{N3} = 0.462$，$K_{N5} = 0.053$，$K_{N7} = 0.041$

每相绕组串联的匝数 N=96

$$E_{\phi1} = 4.44 f_1 N K_{N1}\phi_1 = 219.81V$$

$$E_{\phi3} = 4.44 f_3 N K_{N3}\phi_3 = 107.82V$$

$$E_{\phi5} = 4.44 f_5 N K_{N5}\phi_5 = 13.55V$$

$$E_{\phi7} = 4.44 f_7 N K_{N7}\phi_7 = 5.69V$$

则每相电动势为 $E_\phi = \sqrt{E_{\phi1}{}^2 + E_{\phi3}{}^2 + E_{\phi5}{}^2 + E_{\phi7}{}^2} = 245.26V$

（3）由于三相绕组采用星型接法，故在线电动势中不含有三次谐波分量，

则线电动势为：$E_1 = \sqrt{3}\bullet\sqrt{E_{\phi1}{}^2 + E_{\phi5}{}^2 + E_{\phi7}{}^2} = 381.55V$

7-2、设有一三相电机，6 极，双层绕组，星形接法，Z=54，y=7，Nc=10，a=1，绕组中电流 f=50Hz，流入电流有效值 I=16A，试求：旋转磁动势的基波、5 次和 7 次谐波分量的振幅及转速、转向？

解：由已知可得

2p=6、m=3、Z=54、y=7、Nc=10，a=1，f=50Hz

$$\tau=\frac{Z}{2p}=\frac{54}{6}=9 \qquad q=\frac{Z}{2pm}=\frac{54}{6\times3}=3 \qquad \alpha=\frac{p\times360^\circ}{Z}=\frac{3\times360^\circ}{54}=20^\circ$$

$$\beta=(\tau-y)\alpha=(9-7)\times20^\circ=40^\circ \qquad N=\frac{2pqN_c}{a}=6\times3\times10=180$$

$$\therefore\ K_{N1}=K_{d1}K_{p1}=\frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}}\cos\frac{\beta}{2}=\frac{\sin\frac{3\times20^\circ}{2}}{3\times\sin\frac{20^\circ}{2}}\times\cos\frac{40^\circ}{2}=0.96\times0.94=0.902$$

$$K_{N5}=K_{d5}K_{p5}=\frac{\sin\frac{5q\alpha}{2}}{q\sin\frac{5\alpha}{2}}\cos\frac{5\beta}{2}=\frac{\sin\frac{5\times3\times20^\circ}{2}}{3\times\sin\frac{5\times20^\circ}{2}}\times\cos\frac{5\times40^\circ}{2}=0.218\times(-0.174)=-0.038$$

$$K_{N7}=K_{d7}K_{p7}=\frac{\sin\frac{7q\alpha}{2}}{q\sin\frac{7\alpha}{2}}\cos\frac{7\beta}{2}=\frac{\sin\frac{7\times3\times20^\circ}{2}}{3\times\sin\frac{7\times20^\circ}{2}}\times\cos\frac{7\times40^\circ}{2}=-0.177\times(-0.766)=0.136$$

$$F_1=\frac{3}{2}\times0.9\frac{NK_{N1}}{p}I=\frac{3}{2}\times0.9\times\frac{180\times0.902}{3}\times16=1169(A)$$

$$n_1=\frac{60f_1}{p}=\frac{60\times50}{3}=1000(r/\min)$$

$$F_5=\frac{3}{2}\times0.9\frac{NK_{N5}}{5p}I=\frac{3}{2}\times0.9\times\frac{180\times(-0.038)}{5\times3}\times16=-9.85(A)$$

$$n_5=\frac{n_1}{5}=\frac{1000}{5}=200(r/\min)$$ 转向：与基波相反

$$F_7=\frac{3}{2}\times0.9\frac{NK_{N7}}{7p}I=\frac{3}{2}\times0.9\times\frac{180\times0.136}{7\times3}\times16=25.1(A)$$

$$n_5=\frac{n_1}{7}=\frac{1000}{7}=143(r/\min)$$ 向：与基波相同

7-3、设有 4 极三相交流电机，星形接法，50Hz，定子绕组为双层对称绕组，q=3，Nc=4，线圈跨距 y=7，试问流入三相电流为下列各种情况时所产生的磁动势，求出磁动势的性质和基波振幅？

（1）$\begin{cases} i_a = 100\sqrt{2}\sin\omega t \\ i_b = 100\sqrt{2}\sin(\omega t - 120^\circ) \\ i_c = 100\sqrt{2}\sin(\omega t + 120^\circ) \end{cases}$　　（2）$\begin{cases} i_a = 100\sqrt{2}\sin\omega t \\ i_b = 100\sqrt{2}\sin\omega t \\ i_c = 100\sqrt{2}\sin\omega t \end{cases}$

（3）$\begin{cases} i_a = 100\sqrt{2}\sin\omega t \\ i_b = -100\sqrt{2}\sin\omega t \\ i_c = 0 \end{cases}$　　（4）$\begin{cases} i_a = 100\sqrt{2}\sin\omega t \\ i_b = -50\sqrt{2}\sin(\omega t - 60^\circ) \\ i_c = -86\sqrt{2}\sin(\omega t + 30^\circ) \end{cases}$

解： 由已知可得：**Z=2pmq=4×3×3=36，** $\alpha = \frac{p\times 360^\circ}{Z} = \frac{2\times 360^\circ}{36} = 20^\circ$

$\tau = \frac{Z}{2p} = \frac{36}{4} = 9$　　$\beta = (\tau - y)\alpha = (9-7)\times 20^\circ = 40^\circ$

$$N = \frac{2pqN_c}{a} = 4\times 3\times 4 = 48$$

$$K_{N1} = K_{d1}K_{p1} = \frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}}\cos\frac{\beta}{2} = \frac{\sin\frac{3\times 20^\circ}{2}}{3\times\sin\frac{20^\circ}{2}}\times\cos\frac{40^\circ}{2} = 0.96\times 0.94 = 0.902$$

（1）$F_1 = \frac{3}{2}\times 0.9\frac{NK_{N1}}{p}I = \frac{3}{2}\times 0.9\times\frac{48\times 0.902}{3}\times 100 = 2922.5(A)$

合成磁动势是圆形旋转磁动势

（2）F_1=0(三相磁动势对称)

合成磁动势为零

（3）$\begin{cases} f_{1a} = F_{1m}\sin\omega t\sin x \\ f_{1a} = F_{1m}\sin(\omega t - \pi)\sin(x - 120^\circ) \\ f_{1c} = 0 \end{cases}$

$$f_1 = f_{1a} + f_{1b} + f_{1c} = \sqrt{3}F_{1m}\sin\omega t\cos(x - 60^\circ)$$

合成磁动势是单相脉振磁动势

基波幅值：$F_1 = \sqrt{3}\times 0.9\frac{NK_{N1}}{p}I = \sqrt{3}\times 0.9\times\frac{48\times 0.902}{3}\times 100 = 3374.5(A)$